BELL & HOWELL SCHOOLS

ASSEMBLY MANUAL 9550-1

Digital Multimeter

595-1665-05

Dear Customer:

The Heathkit electronic product you have purchased is one of the best performing electronic products in the world.

Here's how we aim to keep it that way:

Your Heathkit Warranty

During your first 90 days of ownership, any parts which we find are defective, either in materials or workmanship, will be replaced or repaired free of charge. And we'll pay shipping charges to get those parts to you — anywhere in the world.

If we determine a defective part has caused your Heathkit electronic product to need other repair, through no fault of yours, we will service it free — at the factory, at any retail Heathkit Electronic Center, or through any of our authorized overseas distributors.

This protection is exclusively yours as the original purchaser. Naturally, it doesn't cover damage by use of acid-core solder, incorrect assembly, misuse, fire, flood or acts of God. But, it does insure the performance of your Heathkit electronic product anywhere in the world — for most any other reason.

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What happens after warranty? We won't let you down. If your Heathkit electronic product needs repairs or you need a part, just write or call the factory, your nearest retail Heathkit Electronic Center, or any Heath authorized overseas distributor. We maintain an inventory of replacement parts for each Heathkit model at most locations — even for many models that no longer appear in our current product line-up. Repair service and technical consultation are available through all locations.

We hope you'll never need our repair or replacement services, but it's nice to know you're protected anyway — and that cheerful help is nearby.

Sincerely,

HEATH COMPANY
Benton Harbor, Michigan 49022

Prices and specifications subject to change without notice.

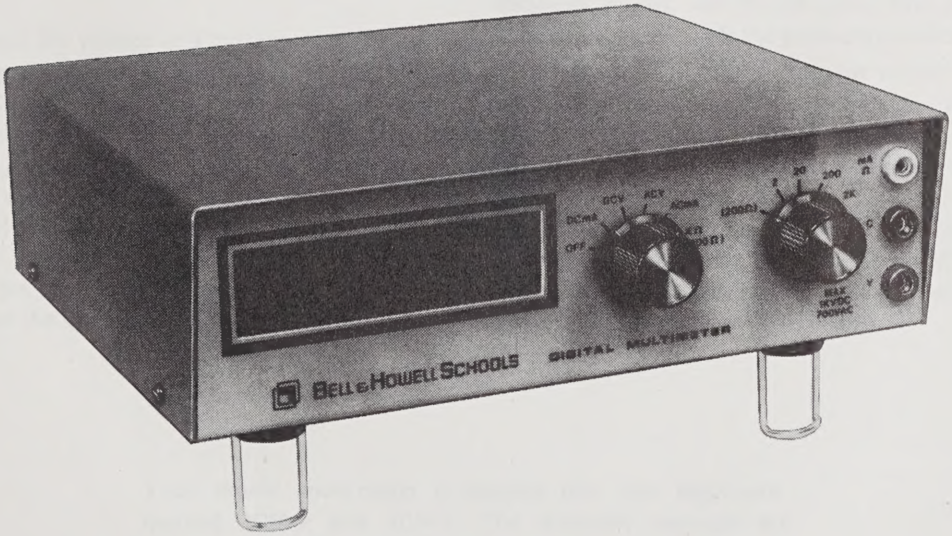
Assembly Manual

for the

BELL & HOWELL SCHOOLS

DIGITAL MULTIMETER

9550-1



BELL AND HOWELL SCHOOLS INC.
4141 Belmont
Chicago, Illinois 60641

TABLE OF CONTENTS

BOOK 1

INTRODUCTION

The Bell and Howell Schools Inc. Digital Multimeter will accurately measure voltage, current, and resistance values and display them on cold-cathode tubes and indicator lamps. Solid-state circuitry is used throughout the instrument for reliability and compactness.

Four ranges are used for voltage and current, both AC and DC. The voltage ranges are 2, 20, 200, and 2 k (2000) volts, although the maximum input voltages are limited to 1000 volts DC and 700 volts rms AC. The current ranges for both AC and DC are 2, 20, 200, and 2 k (2000) mA (2 amperes). The five resistance ranges available are 200 ohms and 2, 20, 200, and 2 k (2000) kilohms (2 megohms).

All DC voltage ranges have a one megohm input impedance so they do not load the circuit being measured. The voltage and current ranges provide an overrange indication by illuminating an indicator lamp. The decimal point is automatically located for each range by the setting of the Range switch.

Overload protection is provided by fuses on the current and resistance inputs, and the AC power line. A 3-wire polarized line cord is used, with the grounded wire connected directly to the chassis and cabinet for user protection. The input C (common) jack is not connected to the chassis. Dual transformer primary windings permit you to wire the multimeter for either 120 or 240 volts AC, 50-60 Hz.

The multimeter is housed in a low-profile, aluminum cabinet. The convenience, versatility, and accuracy of this Digital Multimeter make it a most desirable instrument for the lab, service shop, or ham shack.

Your digital multimeter is divided into two shipments, marked ICM-1 and ICM-2. The assembly manuals are labelled 9550-1 and 9550-2 and correspond to the two shipments. After you complete the first laboratory exam related to circuit theory, return it for grading. A separate manual, labelled 9550-2 Part II, includes special experiments to familiarize you with digital multimeter operation. The second assembly manual will direct you to the special experiments.

PARTS LIST

Unpack all of the parts and check each part against the following list. The key numbers correspond to the numbers on the Parts Pictorial. Any part that is packaged in an individual envelope with a part number on it should be placed back in its envelope, after you identify it, until it is called for in a step.

	KEY No.	PART No.	PARTS Per Kit	DESCRIPTION
RESISTORS				
1/2-Watt, 10%				
NOTE: 10% resistors have a fourth color band of silver				
(X)	A1	1-18	1	5600 Ω (green-blue-red)
(X)	A1	1-21	2	15 kΩ (brown-green-orange)
(X)	A1	1-102	2	82 kΩ (gray-red-orange)
(X)	A1	1-121	2	120 kΩ (brown-red-yellow)
(X)	A1	1-34	1	680 kΩ (blue-gray-yellow)
(X)	A1	1-40	3	10 MΩ (brown-black-blue)
1/2-Watt, 5%				
NOTE: 5% resistors have a fourth color band of gold.				
(X)	A1	1-123	2	100 Ω (brown-black-brown)
(X)	A1	1-147	1	220 Ω (red-red-brown)
(X)	A1	1-94	5	390 Ω (orange-white-brown)
(X)	A1	1-172	6	1000 Ω (brown-black-red)
(X)	A1	1-57	2	2200 Ω (red-red-red)
(X)	A1	1-122	3	3300 Ω (orange-orange-red)
Resistors (cont'd.)				
(X)	A1	1-43	3	4700 Ω (yellow-violet-red)
(X)	A1	1-114	2	8200 Ω (gray-red-red)
(X)	A1	1-105	3	10 kΩ (brown-black-orange)
(X)	A1	1-109	2	12 kΩ (brown-red-orange)
(X)	A1	1-162	2	18 kΩ (brown-gray-orange)
(X)	A1	1-115	1	47 kΩ (yellow-violet-orange)
(X)	A1	1-104	2	100 kΩ (brown-black-yellow)
(X)	A1	1-185	1	180 kΩ (brown-gray-yellow)
(X)	A1	1-87	2	330 kΩ (orange-orange-yellow)
(X)	A1	1-101	4	1 MΩ (brown-black-green)
(X)	A1	1-163	1	6.8 MΩ (blue-gray-green)

PARTS PICTORIAL

A1

	KEY No.	PART No.	PARTS Per Kit	DESCRIPTION
1% Precision				
( )	A2	2-83	1	200 Ω
( )	A2	2-228	1	2000 Ω (2 k)
( )	A2	2-38	1	20 kΩ
( )	A2	2-54	1	200 kΩ
( )	A2	2-55	1	2 MΩ
Other Resistor				
( )	A3	1-19-1	1	220 Ω, 10%, 1-watt (red-red-brown)

CONTROLS

( )	B1	10-382	3	2000 Ω (2 k)
( )	B1	10-383	1	10 kΩ
( )	B1	10-388	1	20 kΩ
( )	B1	10-389	2	100 kΩ
( )	B1	10-384	1	500 kΩ
( )	B1	10-393	1	5 MΩ
( )	B2	10-1009	1	15 kΩ

CAPACITORS

Disc				
( )	C1	21-140	1	.001 μF
( )	C1	21-16	1	.01 μF
( )	C1	21-94	1	.05 μF
( )	C1	21-95	6	.1 μF
( )	C2	21-70	1	.01 μF (1.4 kV)

NOTE: This capacitor may or may not be marked "1.4 KV." However, it is much larger than the other .01 μF capacitor (#21-16).

Mylar*				
( )	C3	27-70	2	.0022 μF
( )	C4	27-1	2	.1 μF
( )	C5	27-86	2	.47 μF
Tantalum				
( )	C6	25-220	3	10 μF (M10)
( )	C7	25-223	2	47 μF (M47)

*DuPont Registered Trademark

	KEY No.	PART No.	PARTS Per Kit	DESCRIPTION
Mica				
( )	C8	20-52	1	7.5 pF
Electrolytic				
( )	C9	25-28	1	100 μF
( )	C10	25-148	1	1000 μF

DIODES

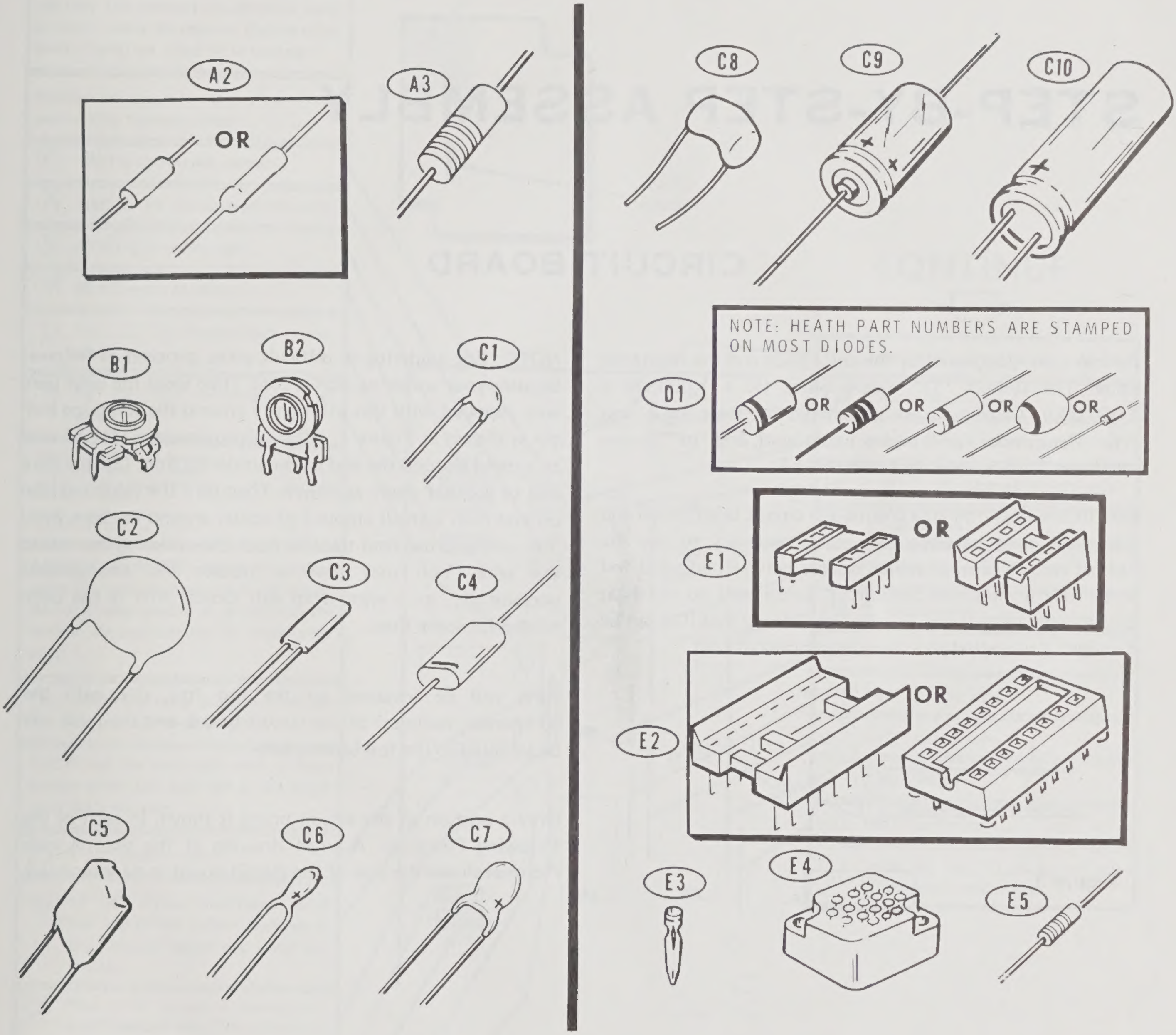
( )	D1	56-56	8	1N4149 diode
( )	D1	57-27	3	1N2071 diode
( )	D1	57-65	3	1N4002 diode
( )	D1	56-25	2	1N4166A zener diode

MISCELLANEOUS

( )	E1	434-230	1	8-pin IC socket
( )	E2	434-298	5	14-pin IC socket
( )	E2	434-299	2	16-pin IC socket
( )	E3	432-134	21	Wire connector (2 extra)
( )	E4	434-234	2	Tube socket
( )		346-1	6"	Sleeving
( )		85-1595-1	1	Circuit board
( )		340-8	33"	Small bare wire
( )		331-8		Solder
				Manual (See front cover for part number.)
( )		340-11	6"	Large bare wire
( )		597-1306	1	Parts Request Form
( )		597-1389	5	Answer Card
( )		100-1612	1	Calibration Voltage envelope containing:
( )	E5		1	*10 kΩ, 1/4-watt, 5% resistor (brown-black-orange)*
( )	E5		1	*22 kΩ, 1/4-watt, 5% resistor (red-red-orange)*
( )	D1	*56-58*	1	*1N709A zener diode*

NOTE: The prices shown on the separate "Heath Parts Price List" apply only on purchases from the Heath Company where shipment is to a U.S.A. destination. Add 10% (minimum 25 cents) to the price when ordering (Michigan residents add 4% sales tax) to cover insurance, postage, and handling. Outside the U.S.A., parts and service are available from your local Heathkit source and will reflect additional transportation, taxes, duties, and rates of exchange.

PARTS PICTORIAL



STEP-BY-STEP ASSEMBLY

CIRCUIT BOARD

Resistors are designated by the color code and the resistance value. The symbol "Ω" means ohms (K = 1,000; M = 1,000,000). Capacitors are designated by their value and type. The symbol "µF" means microfarad, and "pF" means picofarad. 1 µF is equal to 1,000,000 pF.

Due to the small foil area around the circuit board holes and the small areas between foils, it is necessary to use the utmost care to prevent solder bridges between adjacent foil areas. Use a minimum amount of solder and do not heat components excessively. Diodes, transistors, and IC's can be damaged if subjected to excessive amounts of heat.

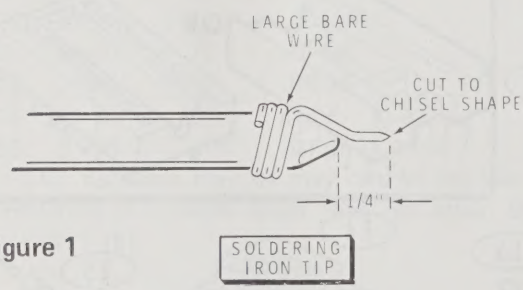


Figure 1

NOTE: For soldering in difficult areas, proceed as follows: Be sure your soldering iron is cool. Then wrap the large bare wire supplied with this kit, tightly around the soldering iron tip as shown in Figure 1. Allow approximately 1/4" of wire to extend beyond the end of the soldering iron. Cut the wire end to a chisel shape as shown. Then turn the soldering iron on and melt a small amount of solder around the bare wire. This will improve heat transfer from the soldering iron tip to the wire. You may have to replace this arrangement occasionally, as a wire wrap will loosen after it has been heated for some time.

Parts will be installed on the top (the side with the component outlines) of the circuit board, and the leads will be soldered to the foil (other) side.

Only a portion of the circuit board is shown in each of the following Pictorials. A small drawing at the top of each Pictorial shows the area of the circuit board to be assembled.

START

NOTE: As you assemble the circuit board, use only 10% resistors (fourth color band of silver) unless 5% resistors (fourth color band of gold) are called for in the step.

Position the circuit board as shown. Then perform the following steps.

( ) 120 kΩ (brown-red-yellow).

( ) 1000 Ω, 5% (brown-black-red-gold).

( ) 82 kΩ (gray-red-orange).

( ) 82 kΩ (gray-red-orange).

( ) 100 kΩ, 5% (brown-black-yellow-gold).

( ) 18 kΩ, 5% (brown-gray-orange-gold).

FOR GOOD SOLDERED CONNECTIONS, YOU MUST KEEP THE SOLDERING IRON TIP CLEAN.

WIPE IT OFTEN WITH A DAMP SPONGE OR CLOTH

SAFETY WARNING: Avoid eye injury when you clip off excess leads. We suggest that you wear glasses, or at least clip the leads so the ends will not fly toward your eyes.

( ) Solder the leads to the foil and cut off the excess lead lengths.

NOTE: Use the small bare wire to make jumper wires. Cut each one to the length specified in the step.

( ) 1-1/4" jumper wire.

( ) 10 MΩ (brown-black-blue). Bend one lead of the resistor as shown in the Pictorial before you install the resistor.

( ) Place a 1/2" length of sleeving on a 1-1/4" jumper wire. Then install the jumper wire as shown.

( ) 10 MΩ (brown-black-blue).

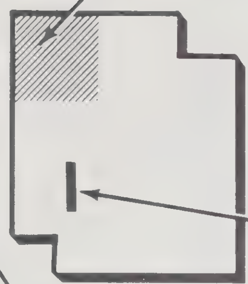
( ) 18 kΩ, 5% (brown-gray-orange-gold).

( ) 1-1/4" jumper wire.

( ) 1-1/4" jumper wire.

( ) Solder the leads to the foil and cut off the excess lead lengths.

The steps performed in this Pictorial are in this area of the circuit board.



CONTINUE

( ) 1000 Ω, 5% (brown-black-red-gold).

( ) 1-1/4" jumper wire.

( ) 120 kΩ (brown-red-yellow).

( ) 1000 Ω, 5% (brown-black-red-gold).

( ) 1" jumper wire.

( ) 2-1/4" jumper wire

( ) 2" jumper wire.

( ) 1-1/4" jumper wire.

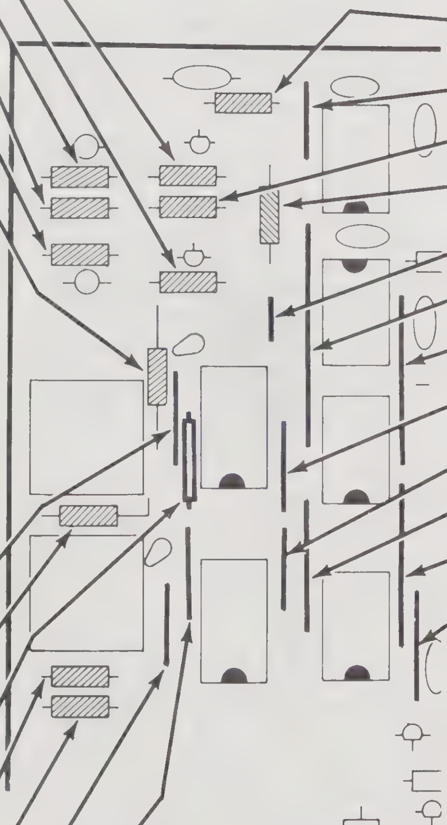
( ) 1-1/4" jumper wire.

( ) 1-1/2" jumper wire

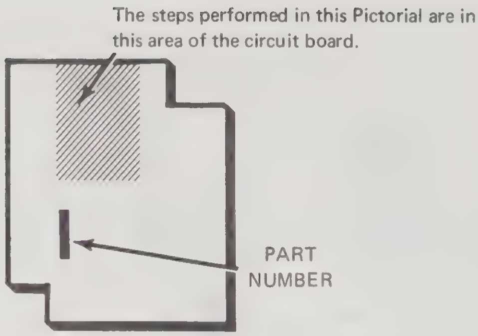
( ) 2" jumper wire.

( ) 1-1/2" jumper wire.

( ) Solder the leads to the foil and cut off the excess lead lengths.

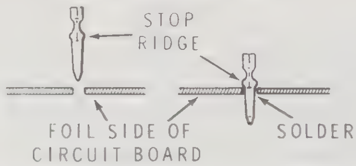


PICTORIAL 1-1



START

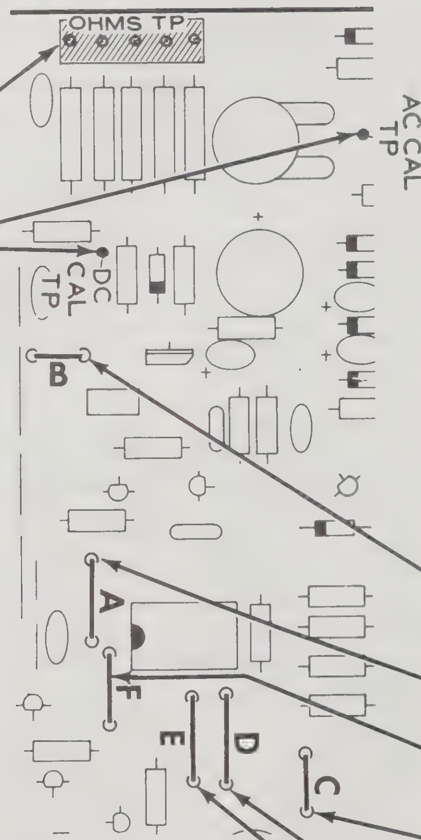
NOTE: Install wire connectors in the following steps as shown. Solder each connector to the foil as you install it.



( ) Five wire connectors within the outline marked "OHMS TP".

( ) One wire connector at the hole marked "AC CAL TP".

( ) One wire connector at the hole marked "DC CAL TP".



PICTORIAL 1-2

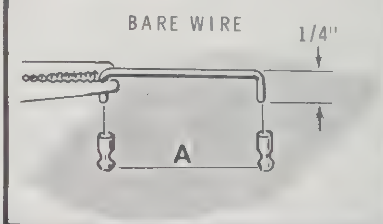
CONTINUE

NOTE: in the following steps, jumper wires will be installed along with the wire connectors. Use the following procedure to perform each step.

1. Install and solder two wire connectors at the location shown in the step.

2. Cut the bare wire to the length specified in the step. Then bend the wire at right angles 1/4" from each end.

3. Use a pair of long-nose pliers to push the wire ends down into the connectors. Do not solder the jumper wires to the connectors.



( ) 7/8" jumper wire with connectors at B.

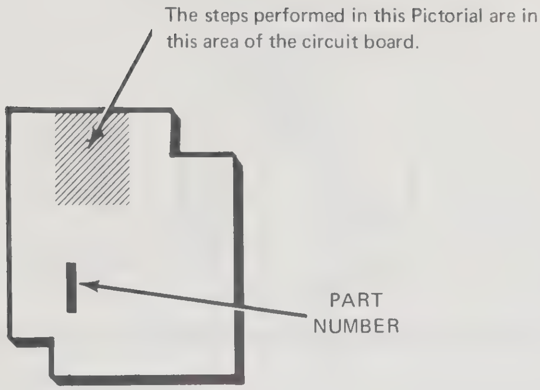
( ) 7/8" jumper wire with connectors at A.

( ) 7/8" jumper wire with connectors at F.

( ) 7/8" jumper wire with connectors at C.

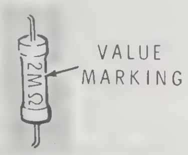
( ) 1-1/8" jumper wire with connectors at D.

( ) 1-1/8" jumper wire with connectors at E.



START

NOTE: In the following steps, install the precision resistors with their value markings up, as shown below, so they can be easily read.



( ) 2 MΩ precision resistor.

( ) 200 kΩ precision resistor.

( ) 20 kΩ precision resistor.

( ) 2000 Ω (2 k) precision resistor.

( ) 200 Ω precision resistor.

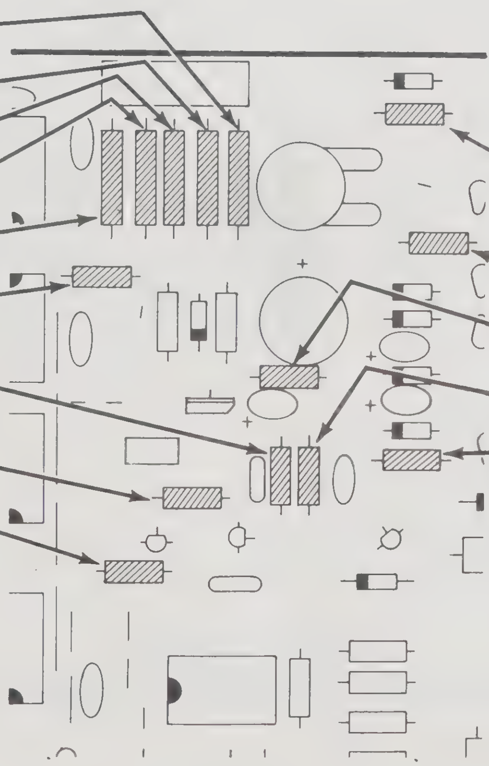
( ) 10 kΩ, 5% (brown-black-orange-gold).

( ) 3300 Ω, 5% (orange-orange-red-gold).

( ) 8200 Ω,5% (gray-red-red-gold).

( ) 3300 Ω, 5% (orange-orange-red-gold).

( ) Solder the leads to the foil and cut off the excess lead lengths.



CONTINUE

( ) 1 MΩ, 5% (brown-black-green-gold).

( ) 180 kΩ, 5% (brown-gray-yellow-gold).

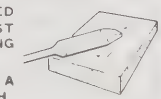
( ) 3300 Ω, 5% (orange-orange-red-gold).

( ) 15 kΩ (brown-green-orange).

( ) 1000 Ω, 5% (brown-black-red-gold).

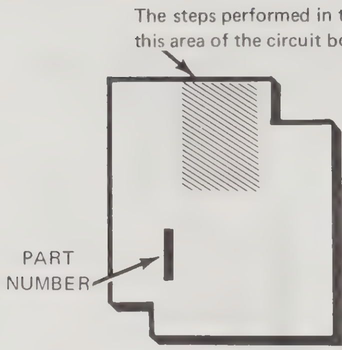
FOR GOOD SOLDERED CONNECTIONS, YOU MUST KEEP THE SOLDERING IRON TIP CLEAN...

WIPE IT OFTEN WITH A DAMP SPONGE OR CLOTH.



( ) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 1-3



START

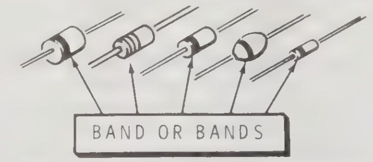
( ) Locate the envelope marked "100-1612 Calibration Voltage" and record the calibration voltage here. Calibration Voltage 1.000
This information will be used later to calibrate your Multimeter.

( ) 22 kΩ, 5%, 1/4-watt (red-red-orange-gold) from Calibration Voltage envelope.

( ) 10 kΩ, 5%, 1/4-watt (brown-black-orange-gold) from Calibration Voltage envelope.

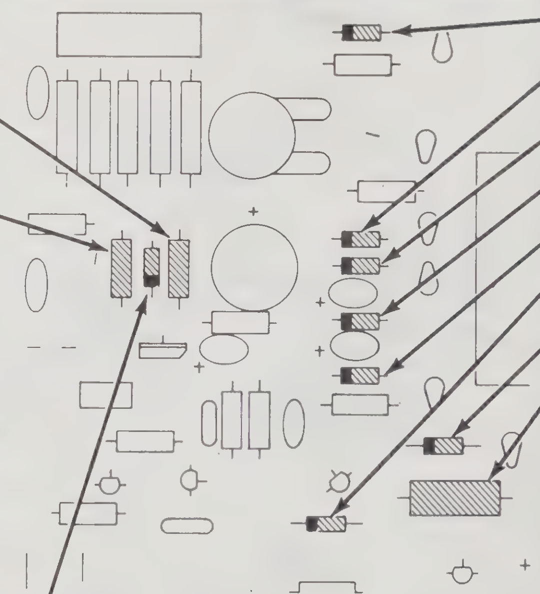
NOTE 1: If at any time you are in doubt about which is the banded (cathode) end of a diode, use the same procedure you used during your "Fundamental Lab Experiments" to check the diode.

NOTE 2: DIODES MAY BE SUPPLIED IN ANY OF THE FOLLOWING SHAPES. ALWAYS POSITION THE BANDED END AS SHOWN ON THE CIRCUIT BOARD.



( ) 1N709A diode #56-58 from Calibration Voltage envelope) at D10.

( ) Solder the leads to the foil and cut off the excess lead lengths.



CONTINUE

( ) 1N2071 diode (#57-27) at D16.

( ) 1N4002 diode (#57-65) at D11.

( ) 1N4002 diode (#57-65) at D12.

( ) 1N4166A diode (#56-25) at D15.

( ) 1N4166A diode (#56-25) at D14.

( ) 1N4149 diode (#56-56) at D17.

( ) 1N4002 diode (#57-65) at D13.

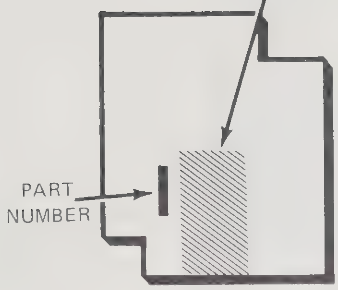
( ) 220 Ω, 1 watt (red-red-brown).

( ) Recheck each diode to make sure the banded end is positioned properly.

( ) Solder the leads to the foil and cut off the excess lead lengths.

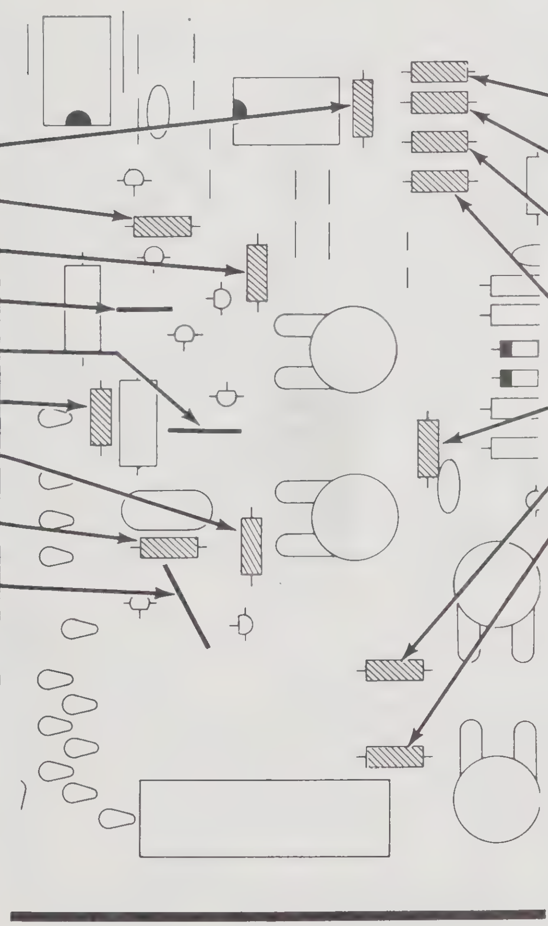
PICTORIAL 1-4

The steps performed in this Pictorial are in this area of the circuit board.



START

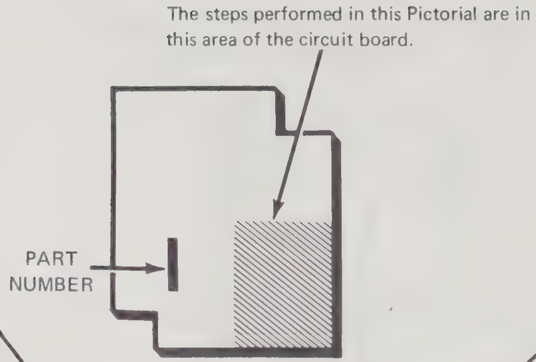
- ( ) 390 Ω, 5% (orange-white-brown-gold).
- ( ) 2200 Ω, 5% (red-red-red-gold).
- ( ) 2200 Ω, 5% (red-red-red-gold).
- ( ) 1" jumper wire.
- ( ) 1-1/4" jumper wire.
- ( ) 1 MΩ, 5% (brown-black-green-gold).
- ( ) 1000 Ω, 5% (brown-black-red-gold).
- ( ) 100 Ω, 5% (brown-black-brown-gold).
- ( ) 1-1/4" jumper wire.
- ( ) Solder the leads to the foil and cut off the excess lead lengths.



CONTINUE

- ( ) 390 Ω, 5% (orange-white-brown-gold).
- ( ) 390 Ω, 5% (orange-white-brown-gold).
- ( ) 390 Ω, 5% (orange-white-brown-gold).
- ( ) 390 Ω, 5% (orange-white-brown-gold).
- ( ) 10 kΩ, 5% (brown-black-orange-gold).
- ( ) 220 Ω, 5% (red-red-brown-gold).
- ( ) 4700 Ω, 5% (yellow-violet-red-gold).
- ( ) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 1-5



START

( ) 15 kΩ (brown-green-orange).

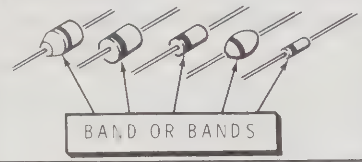
( ) 10 MΩ (brown-black-blue).

( ) 10 kΩ, 5% (brown-black-orange-gold).

( ) 1 MΩ, 5% (brown-black-green-gold).

( ) 5600 Ω (green-blue-red).

NOTE: DIODES MAY BE SUPPLIED IN ANY OF THE FOLLOWING SHAPES. ALWAYS POSITION THE BANDED END AS SHOWN ON THE CIRCUIT BOARD.



( ) 1N4149 diode (#56-56) at D5.

( ) 1N4149 diode (#56-56) at D4.

( ) 330 kΩ, 5% (orange-orange-yellow-gold).

( ) 4700 Ω, 5% (yellow-violet-red-gold).

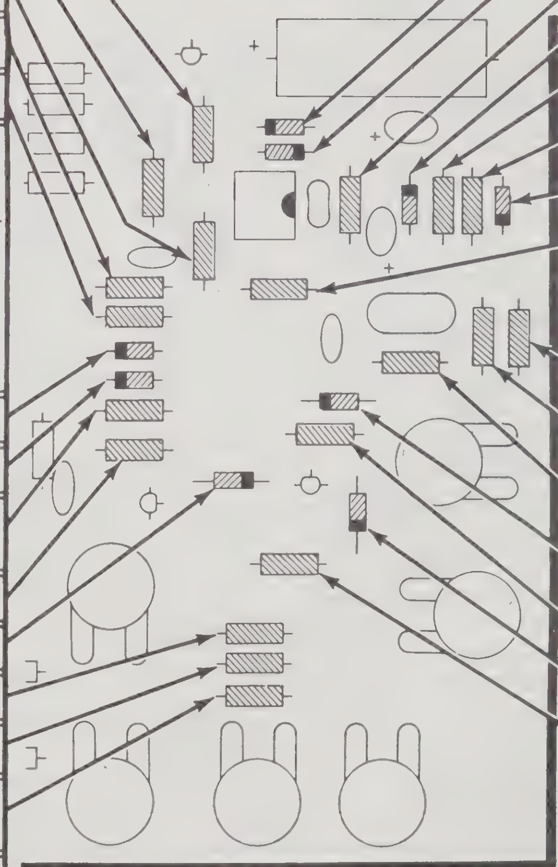
( ) 1N4149 diode (#56-56) at D3.

( ) 6.8 MΩ, 5% (blue-gray-green-gold.

( ) 680 kΩ (blue-gray-yellow).

( ) 47 kΩ, 5% (yellow-violet-orange-gold).

( ) Solder the leads to the foil and cut off the excess lead lengths.



CONTINUE

( ) 1N4149 diode (#56-56) at D7.

( ) 1N4149 diode (#56-56) at D6.

( ) 1 MΩ, 5% (brown-black-green-gold).

( ) 1N4149 diode (#56-56) at D8.

( ) 12 kΩ, 5% (brown-red-orange-gold).

( ) 12 kΩ, 5% (brown-red-orange-gold).

( ) 1N4149 diode (#56-56) at D9.

( ) 1000 Ω, 5% (brown-black-red-gold).

( ) Solder the leads to the foil and cut off the excess lead lengths.

( ) 4700 Ω, 5% (yellow-violet-red-gold).

( ) 100 kΩ, 5% (brown-black-yellow-gold).

( ) 330 kΩ, 5% (orange-orange-yellow-gold).

( ) 1N2071 diode (#57-27) at D1.

( ) 8200 Ω, 5% (gray-red-red-gold).

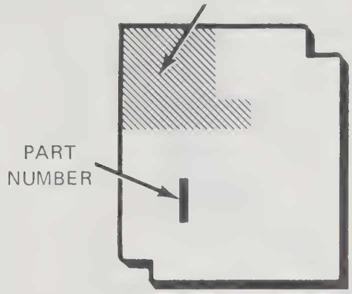
( ) 1N2071 diode (#57-27) at D2.

( ) 100 Ω, 5% (brown-black-brown-gold).

( ) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 1-6

The steps performed in this Pictorial are in this area of the circuit board.

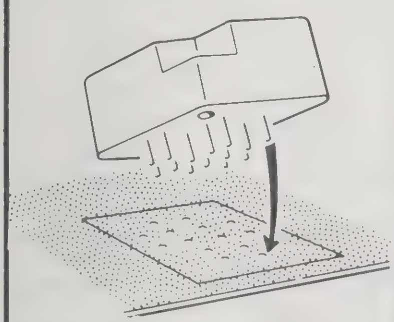


IDENTIFICATION DRAWING

START

NOTE: Read this information carefully before you install the sockets in the following steps. First, be sure to position the socket as shown. Then solder the pins of each socket when you install it.

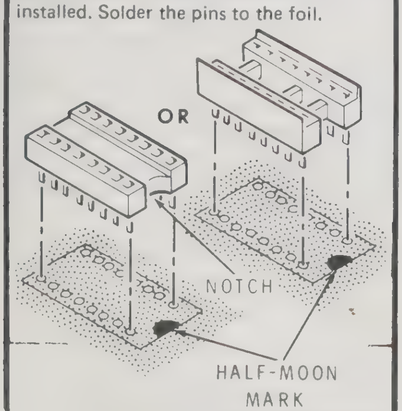
CAUTION: The tube socket and IC socket pins are very close together. Therefore, be sure you do not bridge solder between pins on different foils. When you remove the soldering iron, move the tip of the iron straight up from the pin to avoid bridging solder to another pin. Do not place the soldering iron tip between the socket pins when soldering, as this increases the possibility of a solder bridge.

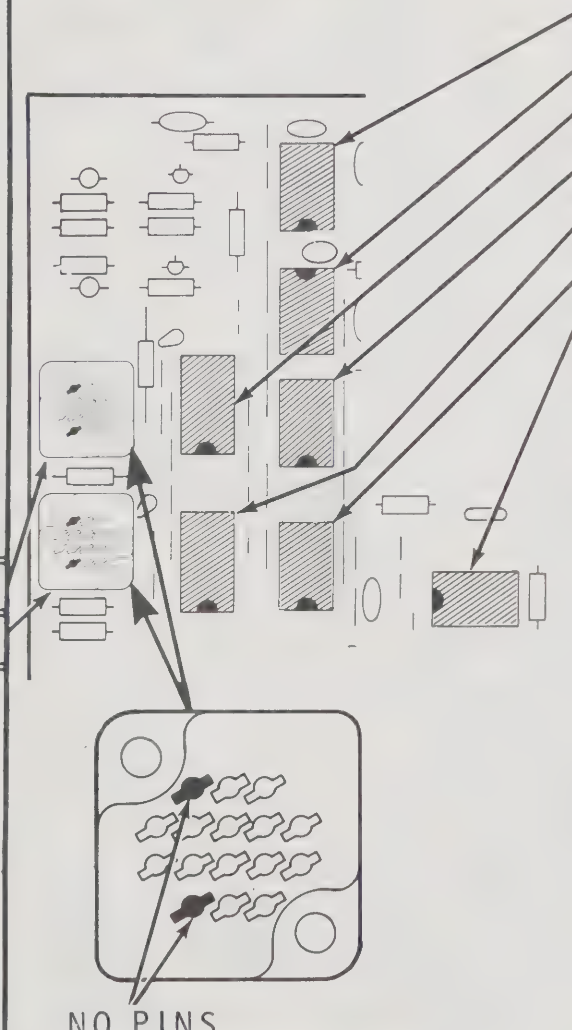


( ) Tube socket at V2.

( ) Tube socket at V1.

NOTE: Both 14-pin and 16-pin dual-in-line IC's and sockets are used in this kit. Be very careful when you install the sockets, as it is possible to place a 14-pin socket in a 16-pin socket location by mistake. Insert the socket pins into the holes. The half-moon mark on the circuit board should still be visible after it is installed. Solder the pins to the foil.





CONTINUE

Solder each IC socket to the foil as you install it.

( ) 14-pin IC socket at IC5.

( ) 14-pin IC socket at IC8. Note the position of the notched end.

( ) 16-pin IC socket at IC3.

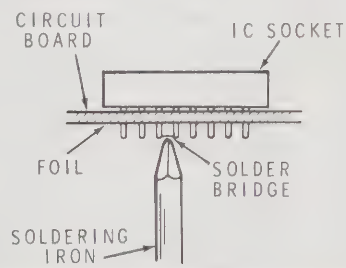
( ) 14-pin IC socket at IC6.

( ) 16-pin IC socket at IC4.

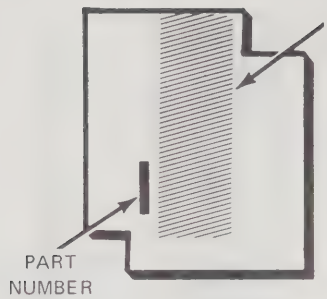
( ) 14-pin IC socket at IC7.

( ) 14-pin IC socket at IC2.

Carefully check each socket for solder bridges between pins. If a solder bridge has occurred, hold the circuit board foil-side-down as shown, and hold the soldering iron tip between the two points that are bridged. The solder will flow down the soldering iron tip.

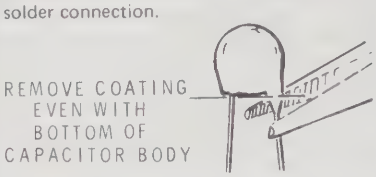


PICTORIAL 1-7



START

NOTE: Check the leads of each disc, mica or Mylar capacitor as you install it. Remove the coating from each capacitor as shown. This coating could cause a bad solder connection.

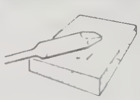


- (X) .1 μF disc.
- (X) .1 μF disc.
- (X) .001 μF disc.
- (X) .05 μF disc.
- (X) .0022 μF Mylar.
- (X) .0022 μF Mylar.
- (X) .1 μF disc.

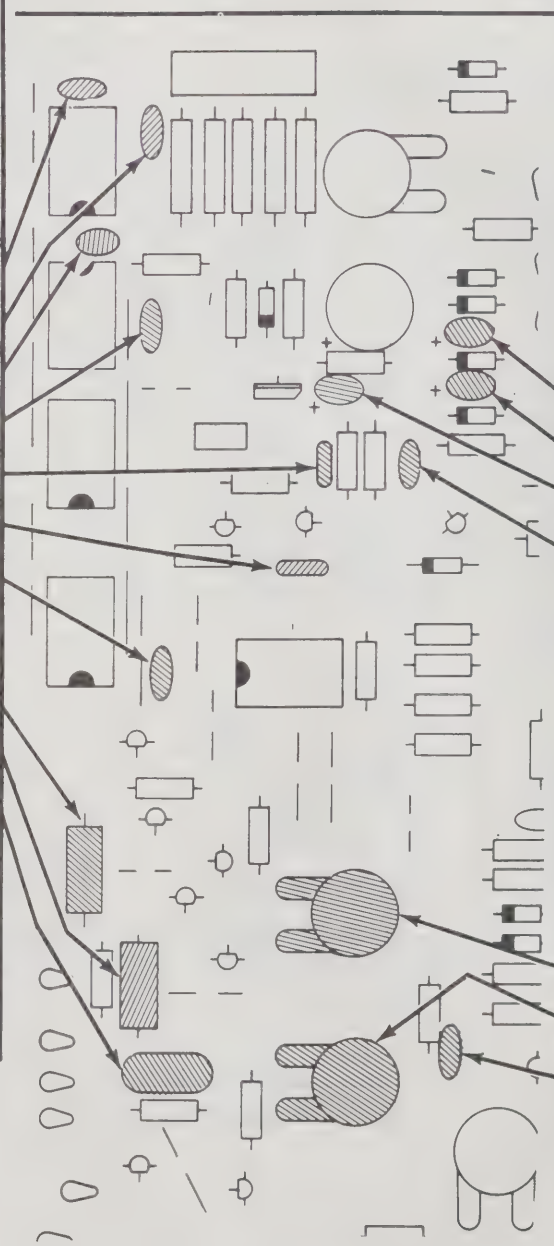
NOTE: Disregard the banded end on the Mylar capacitors in the following steps.

- (✓) .1 μF Mylar.
- (✓) .1μF Mylar.
- ( ) .47 μF Mylar.

FOR GOOD SOLDERED CONNECTIONS, YOU MUST KEEP THE SOLDERING IRON TIP CLEAN. WIPE IT OFTEN WITH A DAMP SPONGE OR CLOTH.



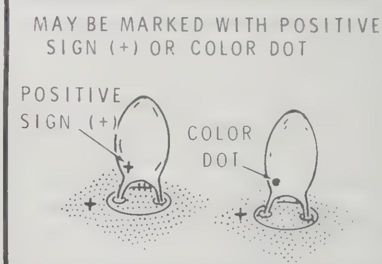
- (✓) Solder the leads to the foil and cut off the excess lead lengths.



CONTINUE

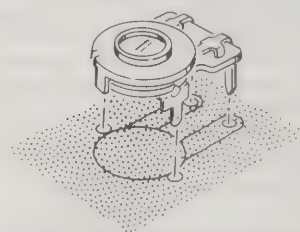
Solder each part to the foil as it is installed.

NOTE: Tantalum capacitors may be marked two ways, as shown. When you install the following capacitor, be sure to match the positive (+) sign or color dot with the positive (+) marking on the circuit board.



- (X) 10 μF tantalum (10M).
- (X) 10 μF tantalum (10M).
- (X) 47 μF tantalum (47M).
- (X) .1 μF disc.

NOTE: When you install controls in the following steps, push each control down onto the surface of the circuit board. Then solder all the lugs to the foil.

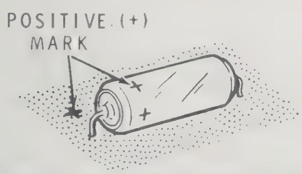


- (✓) 2000 Ω (2 k) control (#10-382).
- (X) 20 kΩ control (#10-388).
- (X) .01 μF disc. Do not use the .01 μF capacitor marked 1.4 kV here.

PICTORIAL 1-8

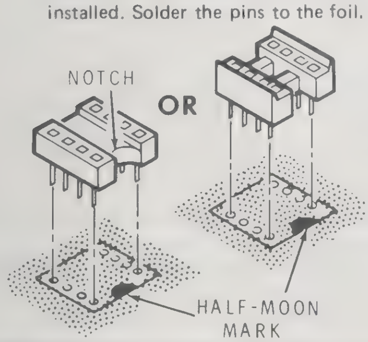
START

NOTE: When you install electrolytic capacitors, always match the positive (+) markings on the capacitor with the positive (+) mark on the circuit board.



(X) 100 μF electrolytic.

(X) 8-pin IC socket at IC1. Insert the socket pins into the holes. The half-moon mark on the circuit board should still be visible after it is installed. Solder the pins to the foil.



(X) .1 μF disc.

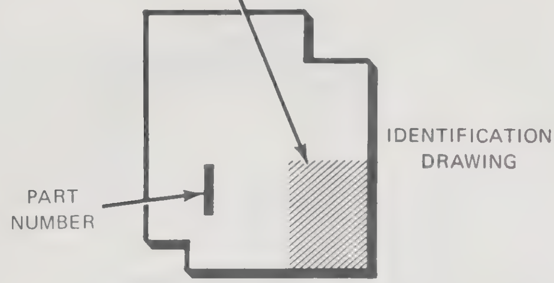
(X) .1 μF disc.

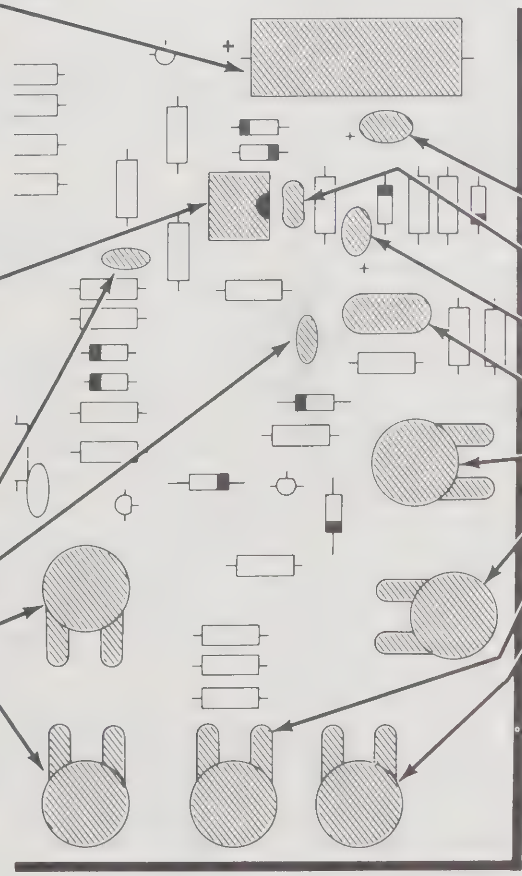
(X) 2000 Ω (2 k) control (#10-382).

(X) 10 kΩ control (#10-383).

(X) Solder the leads to the foil and cut off the excess lead lengths.

The steps performed in this Pictorial are in this area of the circuit board.





CONTINUE

(X) 10 μF tantalum. Make sure the (+) mark is positioned correctly.

(X) 7.5 pF mica.

(X) 47 μF tantalum. Make sure the (+) mark is positioned correctly.

(X) .47 μF Mylar.

(X) 2000 Ω (2 k) control (#10-382).

(X) 5 MΩ control (#10-393).

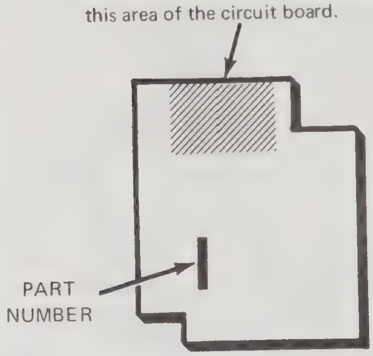
(X) 100 kΩ control (#10-389).

(X) 500 kΩ control (#10-384).

(X) Solder the leads to the foil and cut off the excess lead lengths.

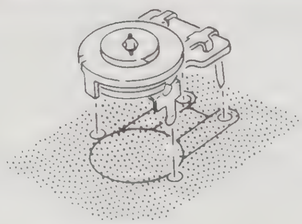
PICTORIAL 1-9

The steps performed in this Pictorial are in this area of the circuit board.



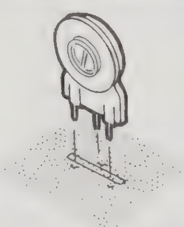
START

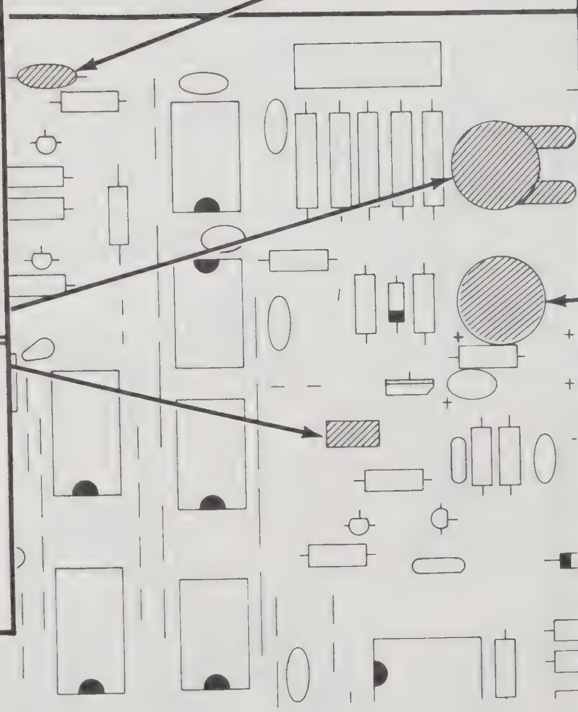
Solder each part to the foil as it is installed.



( ) 100 kΩ control (#10-389).

( ) 15 kΩ control (#10-1009).





CONTINUE

( ) .01 μF disc (1.4 kV).

NOTE: When you install electrolytic capacitors, always match the positive (+) marking on the capacitor with the positive (+) mark on the circuit board.

( ) 1000 μF electrolytic.

CIRCUIT BOARD CHECKOUT

Carefully inspect the circuit board for the following conditions.

( ) Unsoldered connections.

( ) "Cold" solder connections.

( ) Solder bridges between foil patterns.

( ) Protruding leads which could touch together.

( ) Electrolytic capacitors for the correct position of the positive (+) end.

NOTE: Save any remaining parts. They will be used in Book 9550-2.

PICTORIAL 1-10

READ THE "CIRCUIT DESCRIPTION" IN THE FOLLOWING SECTION. THEN, COMPLETE THE EXAMINATION ON PAGE 1-23.

CIRCUIT DESCRIPTION

Refer to the Schematic Diagram (fold-out from Page 1-23) while you read the following description.

To help you locate parts in the Meter or on the Schematic, the resistors, capacitors, and other components are numbered as follows:

100 – 199 and 200 – 299 Parts mounted on the circuit board.

NOTE: Transistors, diodes, integrated circuits, and tubes are numbered without regard to specific grouping.

Selected inputs of resistance, current, or voltage to be measured, are directed through the contacts of the Function switch and through the scaling networks of the Range switch to the input of the A to D (analog-to-digital) converter. Inputs other than DC volts are directed through conversion circuits. The result of switching, scaling, and conversion is that all inputs are converted to a proportional DC voltage level acceptable by the A to D converter.

The analog-to-digital converter converts the input DC voltage to a pulse count during a time period. This time period allows a clock oscillator to generate a number of pulses which are directly proportional to the DC input level. After passing through the decade divider and the decoder driver circuits, the number of gated pulses from the clock oscillator are displayed by the digital readout tubes.

BASIC MEASURING CIRCUIT

The basic measuring circuit is a monopolar analog-to-digital converter using a single ramp technique along with a stable oscillator for long-term accuracy. All inputs are converted to +DC volts before being applied to the A to D converter. Full scale input voltage to the A to D converter is +2 volts DC, regardless of the selected function or range.

If the input exceeds 2 volts DC, it is scaled down to 2 volts or less by the Range switch before it enters the converter. AC voltages are converted to +DC by an average-sensing, rms calibrated operational rectifier circuit. When DC current is measured, a precision resistor is placed in shunt with the input to the A to D converter. For AC current, the shunt resistor is placed across the input to the AC converter. The voltage developed across the shunt resistor is thus measured, rectified if AC, and applied to the input of the A to D converter.

Resistance is measured by routing a calibrated constant current through the unknown resistance. The voltage drop developed across the unknown resistance is applied to the input to the A to D converter.

Timing for the conversion and readout circuits is controlled by the cyclic rate of the AC line frequency. The display tubes are illuminated only during the positive portions of the half-wave rectified high voltage pulses, and the A to D converter is cut off and no oscillator pulses are generated during this time. During the zero-level portion of the rectified high-voltage pulses, the readout is extinguished and a pulse is generated to reset the decade dividers to zero. Then the clock oscillator output is counted. The pulses are routed to the decoder network and applied to the readout tubes before the next half-wave voltage disables the oscillator and turns on the display tubes.

The counting and readout time is equally divided, and both times occur in slightly less than 17 milliseconds for the 60 Hz line frequency, and in 20 milliseconds for a 50 Hz line frequency. Normal persistence of vision does not permit the eye to detect the on-off operation of the readout tubes. Thus the display appears to be constant to the observer and provides a pseudo type of memory for the count.

INPUT SWITCHING

DC Current

DC current is applied to the meter through the mA-Ω jack and the C jack on the front of the Meter. After passing through contacts on wafer 1 of switch SW1, the current is routed to lugs 1 and 3. As the current passes through lug 3 and through a shunt resistor (R106 through R109 selected by switch SW2, a voltage is developed across this shunt. This DC voltage is then applied through lug 1 on wafer 1 of SW1 to the input of the A to D converter (the emitter of transistor Q1).

DC Voltage

When a DC voltage is being measured, it is routed through the V input jack to lug 7 on wafer 1 of SW1 and through the switch contacts to lug 5. The voltage is then applied to a voltage divider network on switch SW2 that consists of precision resistors R101 through R104. A DC voltage developed across this divider, proportional to the input voltage, is routed through SW1 contacts and to the A to D converter input circuit.

AC Voltage

AC voltage is routed in the same manner as DC voltage through the input switching, until it passes through the voltage divider network, R101 through R104, on switch SW2 where a proportionate voltage is developed. This scaled AC voltage is then applied to the AC converter through lugs 16 and 14 of wafer 2 on SW1. The DC output of the AC converter is routed through lugs 7 and 9, to lug 1 on wafer 2 of SW1, and then to the input of the A to D converter.

AC Current

AC current is directed through the Function switch contacts and into the shunt resistors of switch SW2, where a proportional voltage is developed, as in the case of the DC current. This AC voltage developed across a shunt resistor is applied through the AC converter in the same manner as the AC voltage previously described. The resultant DC voltage is routed to the input of the A to D converter.

Resistance

When a resistance is being measured, the mA–Ω input lead is connected through lugs 1 and 3 on wafer 1 of SW1, to lugs 12 and 22 on on wafer 2 of SW1. From this point, the unknown resistance is connected to the collector of constant current source transistor Q10, through resistor R132 and diode D2. Depending on the ohms range selected by SW2, a selected calibrated resistance is placed in the emitter circuit of transistor Q10 and controls the level of the constant current through the circuit. Calibration resistances are composed of resistors R111 and R112 in the 2M circuit, R113 and R114 in the 200K circuit, R115 and R116 in the 20K circuit, R117 and R118 in the 2K circuit, and R119 and R121 in the 200 Ω circuit. A constant current passed through the unknown resistance will develop a voltage that is proportional to the value of that resistance. This voltage is then applied through lugs 1 and 11 on wafer 2 of SW1, to the input of the A to D converter.

Ohms Constant Current Source

Transistors Q9 and Q10; diode D3; and resistors R111 through R119, R121, and R137 are the main components for the OHMS constant current source. Diodes D1 and D2 are protection devices to prevent destruction of this circuit if the input leads are inadvertently connected across a voltage source. Transistor Q9 is connected as a zener diode. Transistor Q9, diode D3, and resistor R137 will maintain a constant bias for Q10, which is determined by the current through the Q10 emitter resistors (R111 through R119 and R121). The variable resistors are adjusted to allow the correct amount of current to flow through Q10 and each of the standard calibration resistors to provide a +2-volt DC level to be applied to the A to D converter for each range selected.

A 200 ohm resistor will require 10 milliamperes of current to develop a 2-volt drop across it. Therefore, resistor R119 is adjusted for a constant current of 10 mA when the Function switch is in the kΩ position, the Range switch is in the 200 Ω position, and a 200 Ω resistor is across the Ω and C input jacks of the Multimeter. Each of the remaining ohms ranges will divide the amount of constant current by ten so that as the range is decaded up, the current is decaded down to maintain a 2-volt DC level for full-scale readings on all five ranges.

AC Converter

The AC converter, which consists of transistor Q8, IC1, and the associated components, functions as an operational rectifier. The gain of the converter is such that the average rectified voltage of a sine wave will produce a DC voltage equal to the rms value of the applied input AC voltage. Capacitor C103 will prevent DC from entering the converter and diodes D4 and D5 are protection diodes to limit the input voltage for safe operation of source follower Q8 (a buffer stage). R153 is for DC stability, D8 and R154 provide negative feedback during negative inputs, and D9 and R155 provide negative feedback during positive inputs. R156 and R167 adjust the gain of IC1 to provide a DC voltage to the input of the A to D converter which is equal to the rms value of the AC voltage input to Q8. R129, R128, and C104 filter the half-wave voltage before it is applied to the A to D converter. C101, R133, and C105 give additional filtering for all inputs regardless of the function.

ANALOG-TO-DIGITAL CONVERTER

Refer to the waveshapes in Figure 2-5 (fold-out from Page 2-44 in Manual 9550-2) while you read the following information.

When a DC voltage is applied to the emitter of transistor Q1, the A to D converter will function as follows:

During time T1 (waveform A), the display is illuminated and the A to D converter is disabled. At the start of T2, the display is extinguished and the base of transistor Q5 goes low (waveform F). This removes the short across capacitor C106 and allows C106 to take on a charge by the current from transistor Q7, a constant current source. This charge is in the form of a ramp (waveform C).

The termination of time T1 also produces a reset pulse (waveform G) to clear the counting circuit (IC's 5, 6, and 7) to zero for the start of another count. At the end of time T2, the voltage across capacitor C106 is at a level that permits transistor Q2 to conduct, lowering the voltage at its collector. This lower voltage at Q2's collector is inverted and amplified by transistor Q6 and applied to the input of IC2, which is wired as an R-S (Set-Reset) flip-flop (see Figure 2-6). The "high" at the reset input, pin 12, produces a "low" at the $\overline{Q}$ output, pin 13. This, in turn, turns off transistor Q3 and then transistor Q2. This forms a short start pulse (waveform D) and produces a "low" at the base of transistor Q12 (waveform J), which removes the short from clock oscillator transistors Q16 and Q15 and allows the oscillator to produce a series of pulses until a stop pulse is generated to disable the oscillator.

As an example, assume a 1-VDC input to the emitter of transistor Q1. This will cause a display of 100 on the readout tubes. When the ramp amplitude reaches the Q1 emitter voltage, plus the .6 to .8 volt forward base-to-emitter drop, Q1 will conduct and quickly lower the Q1 collector voltage. This negative - going pulse is inverted by transistor Q4, which places a "high" on the input of the Stop R-S flip-flop, pins 1 through 6 (see Figure 2-6). The output (pin 1 of IC2) of the Stop R-S flip-flop will go high and allow transistor Q5 to conduct and discharge capacitor C106. This cuts off transistor Q1 to form the stop pulse (waveform E).

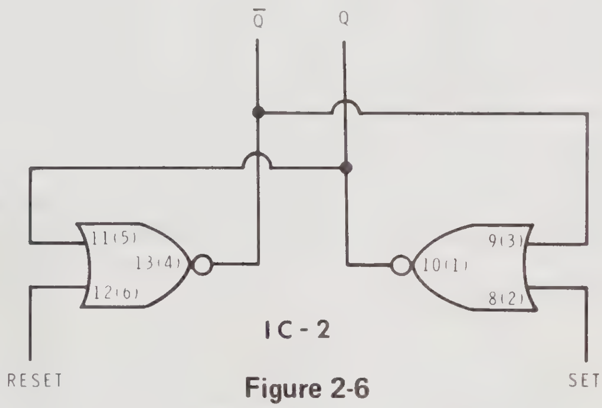


Figure 2-6

The start and stop R-S flip-flops form a latching circuit to control the switching operation of transistor Q12 (waveform J), which controls the on/off period of the clock oscillator (waveform H). The clock frequency is adjusted with R207 so that one volt of DC applied to the emitter of Q1 will produce 100 pulses at the input to the counter circuits.

BINARY TO DECIMAL READOUT

The output string of clock oscillator pulses from the collector of oscillator transistor Q15 is applied to pin 14 of decade counter IC7. In IC7 the pulses are counted, and every tenth pulse (carry pulse) is connected from output pin 11 to input pin 14 of IC6. Once again, each tenth pulse is applied from output pin 11 of IC6 to input pin 1 of IC5.

IC5 is a dual J-K flip-flop, each of which divides its input by two. This first carry pulse from pin 11 of IC6 will produce a "high" at pin 12, the Q output of FF1, allowing Q14 to conduct and illuminate DS202, the "ONE" lamp. The second pulse from IC6 will produce a low at FF1's Q output and extinguish the "ONE" lamp. The Q output of FF1 is connected to the CP input of FF2. The second pulse from the Q output of FF2 will produce a "high" at the base of transistor Q13 and complete the circuit for DS201 and illuminate the "OVER" lamp.

The reset pulse to clear IC5 requires a pulse opposite that of the two decade counters, IC6 and IC7. Therefore, the IC6 and IC7 reset pulse is inverted by IC8B before it is applied to IC5. In this manner, pulses are counted in units, tens, and hundreds in the decade counter IC's. Decoder drivers, IC3 and IC4, convert the binary count to decimal and drive the corresponding numerals in the readout tubes.

During the period in which the pulses are being coupled into the counter circuits, readout illumination is disabled by the absence of line frequency rectified pulses. When the binary information has been stored in the decoder drivers and the oscillator input is complete, the anode voltage to the readout tubes is raised to a high level and the appropriate numerals are illuminated. The repetition rate is such that the output display appears to be continuous to the observer.

POWER SUPPLY

The blue-leads winding of the power transformer, diodes D11 and D12, capacitor C114, zener diode D10, and transistor Q11 make up the regulated +5-volt DC power supply. The black lead of the transformer is the center tap for this full-wave winding and is connected to the Multimeter circuit ground. Transistor Q11 is a zener-controlled, Darlington, pass-transistor stage. The output voltage at the emitter of Q11 remains constant over a wide range of input voltage and output load and current. Diode D10 and resistors R148 and R149 are factory-selected components which provide an accurate, near-full-scale voltage reference for DC calibration.

The +15-volt and -15-volt supply consists of a secondary winding (with yellow leads) of the power transformer; diode D13; capacitors C117, C115, and C116; resistor R158; and zener diodes D14 and D15. Because of the uniformity of the current demand, a pass transistor is unnecessary. Resistor R151 limits the current to zener diode D10. The junction between zener diodes D14 and D15 center taps the supply voltage, and references both the positive and negative voltages to ground.

The power transformer winding with the red and black leads, provides a secondary step-up voltage. This voltage enables the readout tubes to be fired at the proper time and also supplies the power for the neon lamps used to illuminate the "1", and "Over" symbols. The rectified AC pulses that control the oscillator and readout timing are derived from this circuit. The black transformer lead also connects this transformer circuit to the circuit and chassis ground.

Resistors R161 and R163, plus AC TP ADJ control R162, provide the Meter with a transfer method for the calibration of the AC converter.

Resistors R218 and R219 in the pulse shaping network of IC8 form a voltage divider to attenuate the half-wave voltage to a level suitable to drive IC8.

The primary winding of power transformer T1 may be wired for a source voltage of either 120-volts or 240-volts AC, 50 to 60 Hz. Capacitor C118 connects the power line ground to circuit ground to eliminate shock hazard and to minimize A to D converter "hunt" while measuring any power line voltage or current.

Separate resistor standards on the circuit board; R123, R124, R125, R126, and R127, permit full-scale calibration of the Meter ohms ranges.

QUESTIONS

IMPORTANT — These instructions **MUST** be accurately followed to avoid loss, or errors in grading.

Indicate your answer on this sheet by filling in the box for the most correct answer to each question.

When all questions have been answered, place the answer card in the proper position to line up the boxes on the card with the boxes on the sheet.

Next, copy the complete lesson code into the space provided on the card, and fill in the answer boxes to correspond with those previously filled in on this sheet.

Before mailing, be certain your correct student number, name and address appear on the card.

LESSON CODE
9550-1

1. A B C D If the wiper of R_{115} is moved towards lug 1,
(A) the constant current source Q_{10} will be cut off. (B) the 2-volt dc level necessary for calibration will decrease. (C) the constant current source, Q_9, will be cut off. (D) the 2-volt dc level necessary for calibration will increase.

2. A B C D Transistor Q_{12}
(A) is the constant current source for the A to D converter. (B) generates the pulses which start and stop the R-S flip-flops of IC_2. (C) generates the pulses which are applied to the decade counter IC_7. (D) generates the pulses which turn the clock oscillator on and off.

3. A B C D An ac current
(A) is fed directly to the A to D converter. (B) is converted to an ac voltage which is applied to the ac converter, the output of which is applied to the A to D converter. (C) is fed through shunt resistors to develop a dc voltage which is applied to the A to D converter. (D) is converted to a dc current and applied to the A to D converter.

4. A B C D IC_5 is
(A) a dual J-K flip-flop which divides its inputs by two. (B) a dual J-K flip-flop which divides its inputs by ten. (C) an R-S flip-flop which divides its inputs by two. (D) an R-S flip-flop which divides its inputs by ten.

5. A B C D If the anode and cathode connections of both D_8 and D_9 (located in the ac converter section) were reversed
(A) the output of IC_1 would go to zero. (B) the output of IC_1 would become negative. (C) the voltage applied to Q_1 (located in the A to D conveter) would be negative. (D) the voltage applied to Q_1 (located in the A to D converter) would double.

6. A B C D

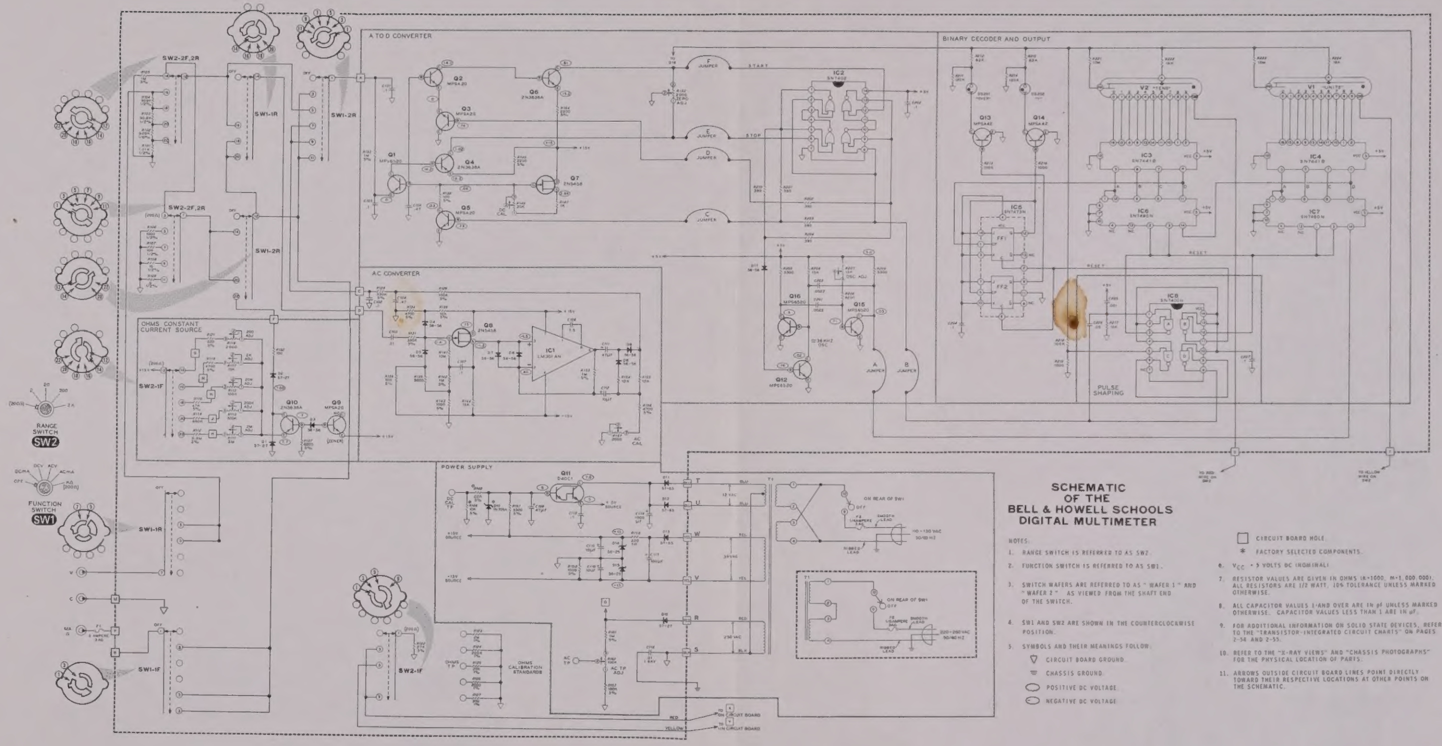
7. A B C D

8. A B C D

9. A B C D

10. A B C D

This examination contains only five questions.



SCHEMATIC
OF THE
BELL & HOWELL SCHOOLS
DIGITAL MULTIMETER

NOTES:

1. RANGE SWITCH IS REFERRED TO AS SW2.
2. FUNCTION SWITCH IS REFERRED TO AS SW1.
3. SWITCH WAFERS ARE REFERRED TO AS " WAFER 1 " AND " WAFER 2 " AS VIEWED FROM THE SHAFT END OF THE SWITCH.
4. SW1 AND SW2 ARE SHOWN IN THE COUNTERCLOCKWISE POSITION.
5. SYMBOLS AND THEIR MEANINGS FOLLOW:
   - CIRCUIT BOARD GROUND.
   - CHASSIS GROUND.
   - POSITIVE DC VOLTAGE.
   - NEGATIVE DC VOLTAGE.
   - CIRCUIT BOARD HOLE.
   - * FACTORY SELECTED COMPONENTS.
6. V_{CC} = 5 VOLTS DC (NOMINAL)
7. RESISTOR VALUES ARE GIVEN IN OHMS (K=1000, M=1,000,000). ALL RESISTORS ARE 1/2 WATT, 10% TOLERANCE UNLESS MARKED OTHERWISE.
8. ALL CAPACITOR VALUES 1 AND OVER ARE IN pF UNLESS MARKED OTHERWISE. CAPACITOR VALUES LESS THAN 1 ARE IN µF.
9. FOR ADDITIONAL INFORMATION ON SOLID STATE DEVICES, REFER TO THE "TRANSISTOR-INTEGRATED CIRCUIT CHARTS" ON PAGES 2-54 AND 2-55.
10. REFER TO THE "X-RAY VIEWS" AND "CHASSIS PHOTOGRAPHS" FOR THE PHYSICAL LOCATION OF PARTS.
11. ARROWS OUTSIDE CIRCUIT BOARD LINES POINT DIRECTLY TOWARD THEIR RESPECTIVE LOCATIONS AT OTHER POINTS ON THE SCHEMATIC.

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